FLIGHT

The Aircraft Engineer & Airships

First Aero Weekly in the World.

Founder and Editor: STANLEY SPOONER

A Journal devoted to the Interests, Practice, and Progress of Aerial Locomotion and Transport

OFFICIAL ORGAN OF THE ROYAL AERO CLUB OF THE UNITED KINGDOM

No. 726. (No. 47, Vol. XIV.) — NOVEMBER 23, 1922 — [Weekly, Price 6d. Post free, 7d.

Flight

The Aircraft Engineer and Airships

Editorial Offices: 36, GREAT QUEEN STREET, KINGSWAY, W.C. 2

Telegrams: Truditur, Westcent, London. Telephone: Gerrard 1828

Annual Subscription Rates, Post Free:

United Kingdom .. 30s. 4*d*. Abroad .. .. 33s. *od*.*

These rates are subject to any alteration found necessary under abnormal conditions and to increases in postage rates

* *European subscriptions must be remitted in British currency*

CONTENTS

DIARY OF FORTHCOMING EVENTS

Club Secretaries and others desirous of announcing the dates of important fixtures are invited to send particulars for inclusion in the following list:

1922.

Nov. 30 .... **Closing date for FLIGHT Glider Designing Competition**

Dec. 1 .... **Lecture, "Constructional Design of Aeroplanes," by C. W. Tinson, before I.Ae.E.**

Dec. 15–Jan. 2 **Paris Aero Exhibition**

1923.

Mar. 15 .... **Entries close for Dutch Height Indicator Competition**

June .... **International Air Congress, London**

Dec. 1 .... **Entries close for French Aero Engine Competition**

1924.

Mar. 1 .... **French Aero Engine Competition**

EDITORIAL COMMENT.

CONSIDERABLE publicity has lately been given to the doings of the Royal Air Force in Iraq, through the articles by Sir Percival Phillips in the *Daily Mail*. The fact that it is the R.A.F. upon which the spotlight has been directed is mainly incidental, and is but a part of the propaganda for the entire evacuation of Iraq which the proprietors of that and other journals have been carrying on for a considerable period. With the arguments used in Sir Percival's articles we are not so much concerned here. He, like many others, appears to overlook the fact that, quite apart from the question of the wisdom or otherwise of spending money upon upholding King Feisul's Government and maintaining law and order, the Persian oil fields are of vast importance to the Empire, and conditions can easily be imagined under which these oil fields might form Britain's only supply of oil fuel. Thus, whether we like it or not, we must defend the pipe line from Basra to Jaffa, and that being so, nobody would seriously claim that this task could be more cheaply or more efficiently done than by the R.A.F. Amid all the wild talk about protection of the poor Arab, killing women and children, "Government by Bomb," and all the rest, this salient fact should be kept in mind. It seems fairly probable that those who now clamour loudest for the evacuation of Iraq would be the first to cry out loud and long about lack of foresight, should the pipe line and, through that, the oil supplies in Persia be cut off and the supply of oil fuel for our Navy and petrol for our aircraft, motor transport, etc., be endangered. At that we are content to let the matter rest as far as the necessity for our being in Iraq at all is concerned.

The R.A.F. in Iraq

As regards the effectiveness of the R.A.F., even Sir Percival does not deny it. On the contrary, he says, in one of his articles: "Until now, government by bomb as I have described it has been the only really effective form of authority in many parts of Iraq." And, again, as showing another direction in which aircraft has proved its usefulness: "Recent operations in Kurdistan proved the efficacy of

aeroplanes in another way. Turkish bands pressed down from the hills against Sikh outposts, and we had to evacuate Sulaimaniyeh and Rania hurriedly. . . . Between dawn and noon next day a succession of aeroplanes flew into the town and took away some sixty persons and the detachment of Arab levies."

Thus, whatever may be one's opinion of the wisdom of our being in Iraq at all, the justification of handing over the command of Iraq to the Royal Air Force appears to be rapidly forthcoming, and we have not the slightest doubt that in Sir John Salmond the R.A.F. in Iraq has a chief, a man of action, who has been given full authority, and who is not afraid to use it to the best advantage.

Exit Hendon

It was with extreme regret that we learned recently that in a short while Hendon as we knew it will be no more. The extension of the Tube from Golders Green, instead of, as we had hoped, being an opening for civil aviation and causing most of our sporting aviation to revert to the old aerodrome, has had an entirely different effect. The aerodrome, we understand, is being split up into building plots, and thus the chance of restoring Hendon's former greatness as an aviation centre vanishes for ever. We shall not attempt to deny that we are sorry. Hendon was always connected in our thoughts with the earliest—and glorious—days of flying. From the Circuit of Britain to the Aerial Derby in 1921, all important flying events took place at Hendon. Hendon was the scene of many early struggles to master the air, and it was the scene of many a glorious race. Everybody who was anybody could be found at Hendon on Saturdays and Sundays, and the popularity of the aerodrome could be gauged by the "gate." Although there was never a great deal of shouting and no big prizes, a week-end at Hendon was never wasted, and the Saturday races under the clever organisation of the late and ever-to-be-regretted Richard Gates, small as they were, were usually more full of entertainment than the more formal flying meetings Waddon has seen.

And now Hendon is no more. With the advent of the Tube, presumably the ground has become too valuable to retain for the problematic use as an aerodrome, and has been given over to the prosaic, but immediately useful, purpose of carrying rows upon rows of "semi-detached." In a few years' time we shall be able to take our children up to the top of the hill by the old church—the mere mention of the edifice brings back memories—and point out to them that down there, just beyond the railway, Britain grew her wings and made her early fledgling attempts at conquering the air; there worked many of the pioneers to whom Britain owes her position in the air today.

England's First Gliding School

Elsewhere in this issue we publish a few notes dealing with the opening of what may be considered England's first school of gliding. If the sport of motorless flight is to become what we all hope for, it is essential that the greatest possible number of enthusiasts should be attracted to the practical, no less than to the theoretical, side. At first it is to be expected that a goodly proportion of those who take up gliding and soaring will be recruited from the ranks of pilots or ex-pilots, who see in this form of flying a means of "keeping their hands in."

We are convinced, however, that the new sport will soon spread outside the relatively narrow limits of those who have in the past been associated with aviation in one form or other, and the formation of a school for the training of glider pilots should help materially in this respect. The fee asked is to be so reasonable that large numbers should be in a position to afford it.

Apart from the training specially for glider pilots (and incidentally the Royal Aero Club will soon have to draft a set of rules defining the tests which a pupil should be able to pass in order to be considered entitled to a glider pilot's licence), the practice obtained on motorless aircraft should be a very valuable asset when and if the pupil decides to go over to power-driven machines. It is not difficult to envisage a system of tuition comprising a series of carefully graduated steps by which a pupil starts on a slow, stable, easily controlled glider; from that proceeds to a more highly-loaded and efficient monoplane; from that, possibly, to a very low-powered machine, and so by easy stages to the full-powered military or commercial aircraft. Should it prove to be the case that preliminary training on gliders was an asset in the training of pilots for power machines, it would appear that it might easily be worth while for the Air Ministry to grant a small subsidy to glider schools for each pupil trained, as his preliminary training on gliders might very easily have the effect of considerably reducing the expense of later training on power-driven aircraft.

Recruiting for London Air Defence

RECRUITING is now open for the first Territorial Battalion of Royal Engineers, to be formed under the War Office scheme for defending London against aerial attack.

The new unit is designated the 10th (London) Anti-Aircraft Battalion, Royal Engineers, and the training of the battalion, which is of scientific nature, will consist of operating the searchlight projectors, engines and sound locators. Men of a high standard are being selected, and engineering students and men with technical knowledge in electrical or mechanical engineering are particularly asked to join.

The rate of pay during camp or if embodied will be 9*s*. a day for sergeant, 5*s*. to 7*s*. 3*d*. for corporal and 3*s*. to 6*s*. for sapper, in addition to bounty and, under the usual conditions, marriage allowance. Those desirous of joining should apply any weekday (except Saturday), between 6 p.m. and 8 p.m., at the Headquarters, 10th (London) A.A. Battalion, R.E., Duke of York's School, Chelsea, S.W.

An Aeronautical Library Saved for Britain

THE Council of the Royal Aeronautical Society announces that through the generosity of the Trustees of the Carnegie United Kingdom Trust it has been able to arrange for the purchase of a large number of valuable historical books on aeronautics which would otherwise have shortly been sold to an American purchaser. This purchase, together with the works already possessed by the Society, renders its collection of early and modern aeronautical literature probably unsurpassed in this or any other country. Comprising as it does many early works of extreme rarity, as well as the most modern English and foreign treatises, the Society's library will now form a complete collection of all important works on aeronautics from the XVIIth century down to the present day. In recognition of its appreciation of their generosity, the Council of the Royal Aeronautical Society has, at the request of the Carnegie Trustees, agreed to make the books in the Society's library available for any student in the British Isles through the medium of the Central Library for Students, 9, Galen Place, London, W.C. 1. The Central Library for Students has been formed by the Carnegie Trustees to provide a loan collection for students of technical books which are unsuitable for placing in rural libraries. By receiving permission to use the Royal Aeronautical Society's Library, the Central Library for Students will be spared the necessity of forming a special section devoted to aeronautics.

A REALLY LIGHT LOW-POWERED ENGINE AT LAST?

The German Statax Three-Cylinder Rotary

IF the claims advanced for it can be substantiated, it would appear that the "Statax" three-cylinder rotary two-stroke engine, which has just been produced in Germany, provides a power plant with which very light aeroplanes, such as the recently constructed gliders, should be able to fly quite creditably. The engine in question, which has been designed and built by Herr F. J. M. Hansen, is stated to weigh but 8 kg. (17·6 lbs.) complete with airscrew, while the power is claimed to be 7·5 h.p. This figure does not refer to a short burst at full throttle, but is the power which the engine is guaranteed to develop for long periods.

The accompanying photograph gives an idea of the general arrangement of the engine. The chief feature is that there is no crank-case, in the ordinary sense of the word, but merely a cylindrical induction chamber to which the cylinders are bolted, with their closed ends turned inwards. The outer ends of the cylinders are open, and the pistons have of course, their skirt pointing outwards. It is claimed that the extremely light weight is a result of so designing the engine that all the most highly stressed members work in tension. While this is so to a certain extent, it is somewhat difficult to see how sufficient weight could be saved to give the low figure stated. From the very brief particulars available (from *Flugsport* of November 15, 1922), it is not quite clear how the force of the explosions and centrifugal force is transmitted from the flat steel straps to the connecting rods or their equivalent. It would appear that, instead of connecting rods, the skirt of the pistons is extended outwards, the two extensions carrying lugs for the steel straps coming out from the boss which represents the crank-pin. These steel straps are, it will be seen, bent over the lugs and then twisted so as to be brought edge-on to the air as the engine is turning.

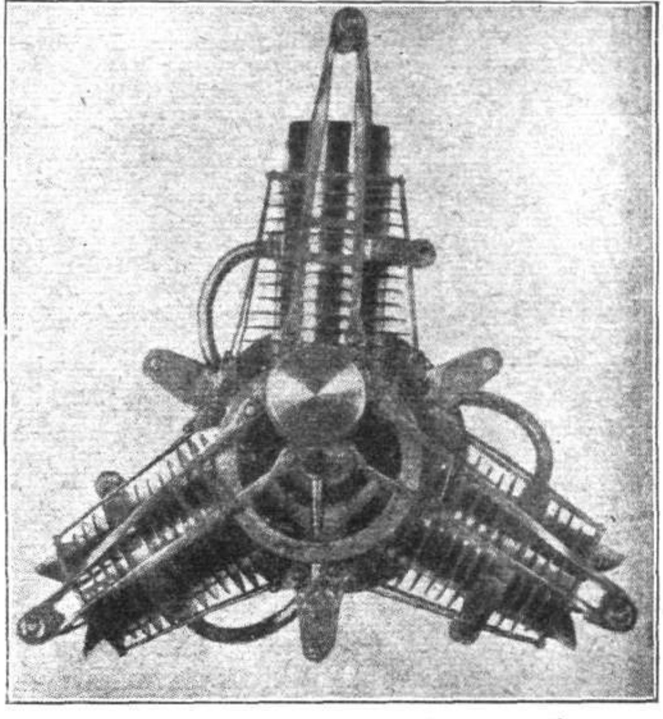
There are no valves, induction and exhaust ports of usual type, closed and opened by the pistons, being used instead. The combustion chamber is, of course, at the inner end of the cylinders, and the mixture is transferred to the combustion chamber through bent induction pipes. Centrifugal force is relied upon to get the charge from the induction chamber out to the cylinders.

The latter are of steel, machined from forgings, and are provided with fins of the usual type. The pistons are made of aluminium alloy, as is also the crank-case, or, more correctly speaking, the induction chamber, which, owing to the tie-rods by which the cylinders are held down, does not have any great centrifugal force to resist. Also, instead of the explosion pressure being added to that of centrifugal force on the cylinders, as it does in ordinary rotaries, it acts in opposition to centrifugal force. It is, of course, through such details that it has been possible to get the weight down.

The propeller blades, of which there are three, are bolted to the induction chamber in the spaces between the cylinders. It would, for this reason, appear to be impossible to cowl-in the engine, and as the combustion chambers are near the foot of the cylinders, probably this portion will require ample cooling, so that a cowl could not be used in any case. The engine would, it might be imagined, be somewhat "dirty," as there does not appear to be any way of collecting the oil flung out.

The magneto fitted is a Bosch of the smallest type, and the plugs are Bosch-Gnome-Lilliput. The magneto is mounted on the back of the engine, as is also the oil pump.

The engine is started by injecting a few drops of petrol through the exhaust ports, when, on swinging the propeller, the engine usually starts after about one-half turn. Owing to the centrifugal induction system it has been found that the engine will not function with any regularity at speeds below 500 r.p.m. The maximum revs. (for long periods) is 1,600 r.p.m. At that speed it may be assumed that the propeller efficiency will not be very good in a slow machine.



Front view of the German Statax engine.

Following are the main dimensions, etc., of the Statax: Bore 60 mm. (2 ins.); stroke, 70 mm. (2¾ ins.); speed, 1,600 r.p.m.; petrol consumption, 320 grammes per h.p./hour (0·705 lb./h.p./hour); oil consumption, 30 grammes/h.p./hour (0·07 lb./h.p./hour); total weight, including a propeller of 4 ft. 11 in. diameter, 8 kg. (17·6 lbs.). These figures, it is stated, are guaranteed.

All enquiries should be addressed to Herr F. J. M. Hansen, 2, Neue Mastrichterstrasse, Cologne.

Members of the New Parliament.

MANY candidates who have been elected to the new Parliament are, or have been, interested or closely associated with aviation—amongst these we notice, and welcome back to his seat, Sir William Joynson-Hicks; also Lieut.-Col. J. T. C. Moore-Brabazon, Admiral M. F. Sueter, and Maj.-Gen. Sir F. Sykes. Possibly a good omen for the future of air matters is the fact that Sir Samuel Hoare, Minister for Air, was the first Minister returned, whilst Sir J. L. Baird, who was a member of the Air Board for the Royal Air Force, appropriately as an air supporter, represents "Ayr" in the House, and it may be noted for this same constituency the Labour candidate, who was defeated, was named Airlie. Many other supporters and well-wishers of aviation are welcome members, including: Capt. W. Brass, a distinguished R.A.F. officer; Comdr. Burney of Imperial Airship fame; Capt. Wedgwood Benn; Rt. Hon. Lord Hugh Cecil (R.F.C. 1915); Capt. A. G. Reid, R.A.F., D.F.C.; Capt. D. Shipwright (R.F.C. 1916); Sir John Simon (R.F.C. 1915–16); Maj. G. C. Tryon (Under Secretary for Air, 1919), etc.

Air Mail to Holland: Reduced Fees

THE Postmaster-General announces that the fees on letters and parcels for conveyance by air to Holland are now reduced. The charge for letters is 2*d*. per oz., instead of 3*d*., in addition to ordinary foreign postage. The rates for parcels are as follow:—Up to 3 lbs., 3*s*. 6*d*. (instead of 4*s*.); from 3-7 lbs., 6*s*. 6*d*. (instead of 7*s*. 6*d*.); from 7-11 lbs., 9*s*. (instead of 10*s*. 6*d*.). The new scale of parcel fees, like the old, is inclusive of express delivery at the place of destination. On parcels addressed "*Poste Restante*," the fees will be 6*d*. less.

India's Air Command

As the result of Air Vice-Marshal Salmond's visit to India, the air command in India has been raised to the dignity of an Air Vice-Marshal's command. Air Vice-Marshal P. W. Game has been appointed to the post in the place of the present commander, Air-Commodore Tom I. Webb-Bowen, air officer commanding R.A.F. in India. The headquarters of the Indian Air establishment will be transferred from Umballa to Delhi.

Seaplane Squadron No. 8, R.N.A.S. Annual.

SEAPLANE SQUADRON No. 8, R.N.A.S., German East Africa, 1916-18, third annual dinner will be held at Gatti's, Strand, on Friday, December 1. Group Capt. F. W. Bowhill, C.M.G., D.S.O., R.A.F., in the chair. All officers and men of R.N.A.S. in East Africa cordially invited. Mufti. Write immediately to C. R. Lucate, 17, Garden Avenue, Mitcham, or C. S. Thompson, 25, Wharncliffe Gardens, N.W. 8.

GLIDING, SOARING AND AIR-SAILING

Those wishing to get in touch with others interested in matters relating to gliding and the construction of gliders are invited to write to the Editor of FLIGHT, *who will be pleased to publish such communications on this page, in order to bring together those who would like to co-operate, either in forming gliding clubs or in private collaboration.*

THERE is still one week in which competitors may send in designs for the Glider Designing Competition for prizes of £25 and £10 offered by the proprietors of FLIGHT. Particulars of the competition were published in our issue of August 31, 1922.

* * *

THE first prize will be awarded to the competitor who sends in the design which, in the opinion of the judges (Mr. F. Handley Page and Mr. C. R. Fairey), gives greatest promise of being efficient, controllable, and of low production cost. A Consolation Prize of £10 will be awarded to the competitor who sends in the most promising design along unorthodox lines, and for which the usual estimates cannot easily be made.

* * *

DESIGNS may be for any type of machine, monoplane, biplane, or triplane, and already it is becoming evident that gliders fall into various classes: The most aerodynamically efficient for soaring flight and competition work; those less efficient may still be very good machines for pure gliding or for school work, while even comparatively crude machines, built from all sorts of odds and ends, may provide quite a good deal of amusement, and need cost but very little.

* * *

THE closing date for the competition is November 30, by which date all designs must be in the hands of the Editor. No designs sent in after that date can be considered for the competition, although this does not necessarily mean that such designs will not be published. The winning drawings become the property of FLIGHT, and will, with others considered of sufficient interest, be published in forthcoming issues.

* * *

ALL drawings, tables, matter, etc., must be marked with a *nom de plume*, and accompanying these a sealed envelope must be sent containing the name and address of the competitor, this envelope to be marked on the outside with the *nom de plume* used on the drawings. Thus designs will be judged solely on merits, without the judges being aware of the identity of competitors.

* * *

SEVERAL items from the German competition in the Rhön appear to us to be of interest to gliding enthusiasts in this country also, and consequently we give below certain facts, features and opinions which have resulted from the German experiments. For most of these we are indebted to that excellent journal *Zeitschrift für Flugtechnik und Motorluftschiffahrt* (usually abbreviated to "Z.F.M.").

FOR this year's Rhön competitions no less than 53 machines had been entered, of which 50 were German. Of the 53 machines, 45 appeared at Rhön, and of these 39 made their appearance before the close of the entries list. Of these 39 gliders 32 were admitted to the acceptance flights, the others being forbidden, for various reasons, to take part. As a result of the acceptance tests 19 only succeeded in passing, and of these 6 were passed as "gliders" only, 13 being passed as "soarers." In order to qualify for the latter category it was necessary to fly for at least 60 secs., or cover a distance of at least 600 metres, with a rate of descent not to exceed 1·5 metres per second.

* * *

IT is of interest to note that the Germans appear to have had much the same trouble with their gliders as we did, *i.e.*, lack of lateral and directional control. In several instances (such as the Hannover "Vampyr" and "Greif") warping was used instead of ailerons, with, it appears, an improvement in control. The warping appears to have taken the form of fairly flexible tips, which could have their camber altered by the warp, rather than a change in incidence without change in section.

* * *

A FEW of the machines had their wings so mounted that the angle of incidence relative to the fuselage could be altered. A notable example is the Darmstadt "Geheimrat," in which the incidence can be changed during flight. To trim the machine a trimming tail plane was used, the controls of which worked on a notched quadrant. In spite of the fact that Hackmack does not appear to have made any extensive use of the trimming tail, several observers are of the opinion that the variable incidence wing form of control was superior to the usual elevator control. Presumably suitable checks were provided so as to prevent the pilot from reducing the angle to such an extent that the machine became unstable.

* * *

THE relatively poor performance of the Hannover "Greif" is put down to the fact that the pilot was seated so deep in the fuselage that his head scarcely protruded, and that therefore he could not feel the wind so well as could pilots of other machines (the Germans used no air speed indicators, it should be remembered). It is also thought that the distance from the c.g. of the machine to the centre of pressure of the rudder was too short. This applies probably also to the majority of the British machines at Itford, all of which had trouble with directional control.

* * *

IN connection with our article on the choice of a wing section for gliders, it is of interest to note that at the Rhön it was found that the machine with the highest value of $(L/D)^2 x\ k_L$ (the Hannover "Vampyr") was also the machine which could reach the greatest height above the top of a

THE WHITELEY BANK SCHOOL OF GLIDING: On the left Mr. Merriam is seen getting out of his machine after a trial flight. Mr. Newman, who had a large share in building the machine, is standing by the nose. On the right, the Merriam-Newman glider is seen just before touching after a flight.

hill. This was, of course, to be expected from theoretical considerations, but it is of interest to know that it was actually proved in practice. The Darmstadt appeared to be as good within its own range, but in trying to gain altitude the "ceiling" of the "Vampyr" always appeared to be about 50 ft. above that of the Darmstadt. Thus the machine with the lowest rate of descent will not only be the best glider in light airs, but it will also, for a given wind strength, be able to reach a higher level above the starting point. For distance gliding this is of great importance.

* * *

PROFESSOR PRANDTL of Göttingen thinks that the variable incidence-*cum*-trimming tail should possess many advantages in a glider, not only for ordinary gliding and soaring in upward currents, but also for gust soaring, as the incidence can be increased much more rapidly than is the case when the whole machine has to be tilted through an angle, as is the case with the ordinary elevator control. He also points out that for getting off without outside assistance this form has possibilities, as a machine can sit on the hillside with the wing at a very small angle; then, during a gust, the incidence can be instantly increased and the machine lifted straight off the ground and commence its glide.

* * *

PRANDTL also suggests the advisability of holding competitions for a number of smaller prizes, the conditions for which are not so severe, as in this way beginners may be attracted who would not otherwise be attracted, and it is only by the constant addition or "new blood" that we can hope to make gliding the popular and valuable sport which it should be. With this opinion we cordially agree, and hope that, in the enthusiasm of great performances, we shall not lose sight of the value of more modest attempts.

* * *

WE are very pleased to learn that our very old friend F. Warren Merriam intends to establish a gliding school in the Isle of Wight. The school, which will be known as the Whiteley Bank School of Gliding, is to start operations as soon as the Merriam-Newman glider has been repaired. The machine will be slightly altered to take a passenger, and will be provided with dual controls, so that school work of a most enjoyable nature should be possible. As there is no engine noise to contend with, the instructor will be able to talk to the pupil in comfort, and the work of tuition should be correspondingly facilitated.

* * *

MERRIAM already has a nice place in "the island" at Whiteley Bank, with a field situated on a slope facing south-west, *i.e.*, into the prevailing winds. Here the preliminary school work will be carried out, while, when pupils have gained a certain measure of proficiency, the scene of operations may be transferred to Arreton Downs.

* * *

THE school fee of the new establishment has been provisionally fixed at £25, which seems very reasonable indeed, and should place the learning of glider piloting within the reach of most enthusiasts. It should further be pointed out that Merriam has room to accommodate the pupils, who will thus be able to live right "on the spot," and need therefore waste no favourable opportunity. The terms for board and lodging will be very moderate, and we cannot conceive of a more enjoyable way of spending a couple of summer months than by living in the "island" and learning to fly.

* * *

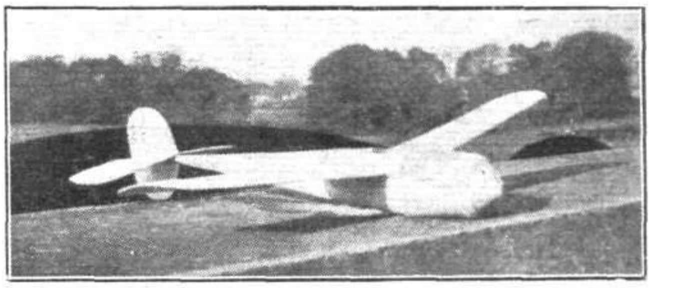
IN connection with the new school it is of interest to learn that one pioneer of aviation has already signified intention of joining the school. This is Mrs. Hewlett, whose name will be familiar to most readers of FLIGHT. Mrs. Hewlett was a partner in the firm Hewlett and Blondeau before the War, and during the War established large works at Luton. It will be a very fitting beginning for Merriam's new school if Mrs. Hewlett is his first lady pupil.

* * *

MERRIAM has probably taught more people to fly than has any other pilot in this country today. During the War he was stationed at Hendon and Chingford, where he taught literally thousands of pupils to fly. That he will be as successful—as regards numbers—may be doubtful, but that his instruction on gliders will be as sound as was that on power machines cannot be doubted for a moment, and we have therefore not the slightest hesitation in recommending the Whiteley Bank School of Gliding to all interested in the new sport and have a desire to take it up in practical form.

* * *

WE understand that there is a possibility of Raynham and Sydney Camm taking the Martinsyde glider (which has been slightly altered since the Itford competition) to Algiers for the great contest which is scheduled to take place there in January of the coming year. We are certain all will wish Raynham better luck than he had in England. Presumably he will test the machine at Itford before taking it abroad.



The Tinson paper model glider, which covered a distance of 920 ft. after being dropped from a water tower 60 ft. high.

* * *

A REPORT from Germany states that a pilot has succeeded in covering a couple of hundred yards over flat country in a glider. The report fails to state at what height the machine started, but presumably it was just "lifted" off, probably by a variable incidence wing, in which case it would appear that some form of "gust soaring" must have taken place.

* * *

THE accompanying photograph of Mr. Tinson's paper model glider should be of interest. This machine has covered a distance of 920 ft. when launched from a water tower 60 ft. high. The photograph was taken just after the model had been retrieved from the water, which explains the somewhat untidy appearance of the tail. Mr. Tinson has sent us the following particulars of his glider: The slots for the wing are marked out on the development of the conical fuselage, and thus the incidence of the main plane to the tail is definitely known, which should be a step in the right direction if we are to make model gliding a science as well as an amusement.

* * *

FOLLOWING are the main particulars of the Tinson paper model glider: Span, 18 ins.; mean chord, $2\frac{1}{2}$ ins.; weight, $1\frac{1}{2}$ ozs.; loading, 0·3 lb./sq. ft.; balance, 0·37 of chord; distance of c.g. from stern post, 3·25 times the chord; incidence of wing to centre line $6\frac{1}{2}$ degrees; incidence of tail to centre line, $5^\circ\ 23'$; elevators to tail, -5° average for best glide, and -1° for soaring in a strong wind.

THE KLEMPERER "ENTE"

An Interesting German Glider Incorporating Many Novel Features

MENTION has been made in our gliding notes from time to time of the tail-first machine or "Ente" (Duck) which Herr Ingenieur Klemperer had produced for this year's Rhön competitions. Unfortunately, the machine was finished late, and there had been no opportunity of making test flights with it when the competition opened. As the machine was of novel design, it is small wonder that a sufficiently thorough trial of it could not be made in time for it to take part in this year's Rhön meeting. Such flights as were made were purely in the nature of test flights, and revealed the fact that several alterations are still necessary before the machine can be considered tuned up. We believe that most of these were necessitated by wrong weight distribution. Before commencing a description of the machine, a drawing of which we reproduce by courtesy of *Zeitschrift für Flugtechnik und Motorluftschiffahrt*, it may be of interest to quote some notes by Herr Klemperer in the same journal.

"The problem of the 'Canard' type," Herr Klemperer writes, "cannot yet be said to have been solved. It is a question of building a 'Canard' type conforming to

modern aerodynamical ideas, especially with regard to incorporating cantilever wings. Secondly, it was to be supposed that particularly for a glider, the front plane might under certain conditions be useful in acting as a 'wind vane.' [The word used by Herr Klemperer is *Windfühler*.—ED., FLIGHT.] The tail-first machine offers favourable possibilities for carrying a passenger without this resulting in making the machine unsuitable for use as a single-seater. In this type the centre of gravity and centre of lift approximately coincide so that, as distinct from the tail-behind type, the c.g. and c.p. of the empty machine are close together. The crew can therefore be placed on the c.g. without the trim of the machine being altered. A further advantage is that the centre of gravity (and, therefore, the seats) does not fall inside the centre-section of the wing, but in front of it. The result is that the wing attachment is simplified, while 'straight-through' wing spars can be used. Finally, the 'Canard' type lends itself to experiments with Lachmann slotted wings, as it can be landed at a much greater angle of incidence than can the tail-behind type.

"Thorough wind tunnel experiments carried out at Friedrichshafen and Göttingen have indicated the suitability of slotted wings on this type of machine, and the results of these tests will be published later. In the actual machine built, the slotted portion was confined to the *ailerons*, owing chiefly to the difficulty of providing a suitable arrangement for opening and closing the wing slots.

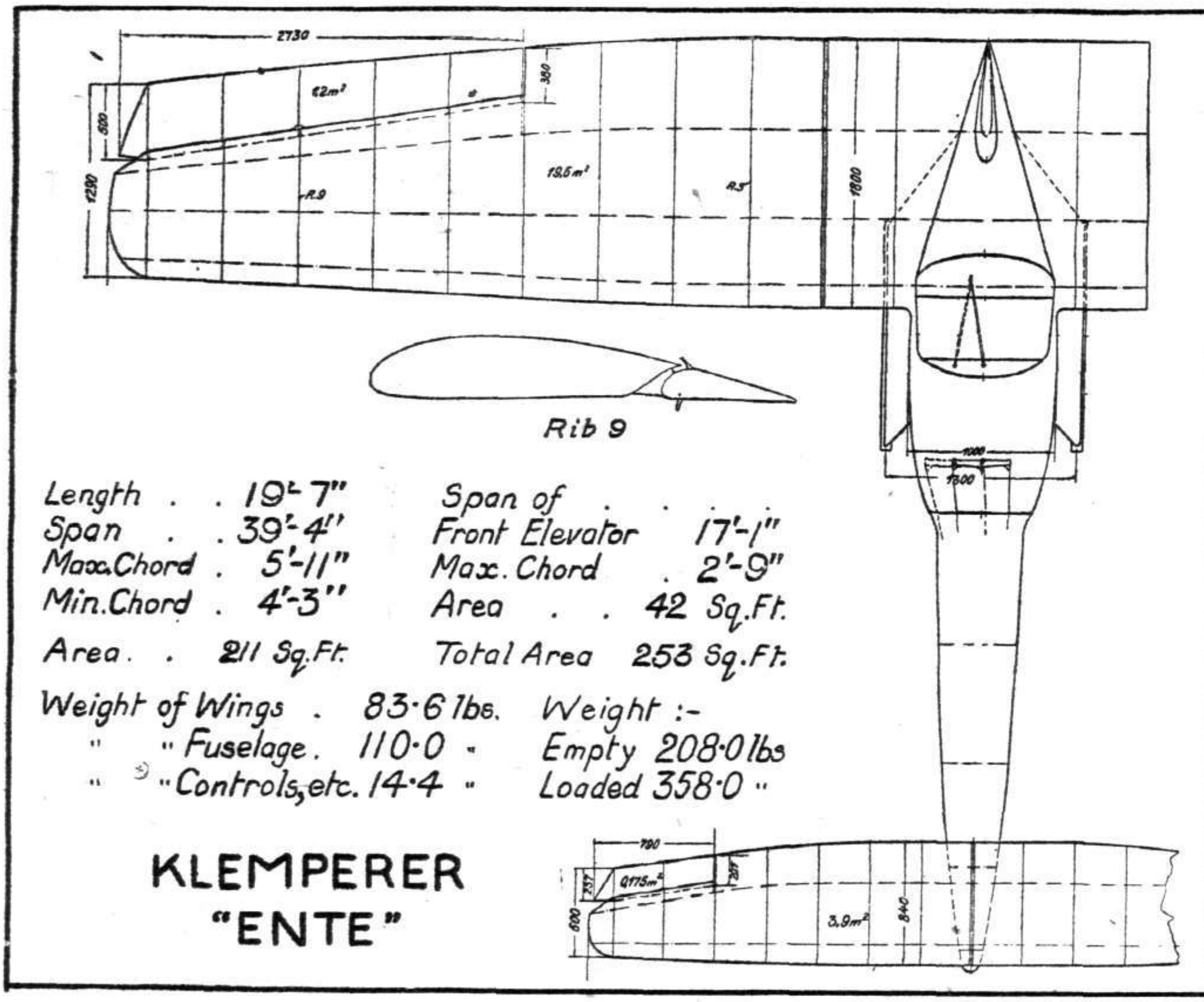
"The tests on the machine carried out up to the present, ten in all, included a few short 'hops.' At first we had trouble with starting the machine. These were overcome by altering the skids, and after the end of the meeting the machine got off very easily. A wind of but 3 to 4 metres per second, and a very short run along the gentle slope running from the top of the 'Kuppe' towards the plantation near the camp was sufficient for getting off. The difficulties which were experienced with directional stability were considerably lessened when a rear rudder, connected up to the front swivelling plane, was fitted.

"Although the 'Canard' type shows great longitudinal stability on tests of models, we found it very difficult on the elevator control. Even after the range of angles through which the front elevator could be moved had been increased, we found that longitudinal stability had not been attained. Evidently the large moment of inertia of this type of machine requires exceptionally large control surfaces. It is possible that difficulty may also be caused by the front plane, on taking off with the front at a considerable height above the ground, getting into a region of stronger wind which, at that low speed of the machine, may have considerable effect.

"The slotted *ailerons* did not behave badly, even in cases of stalling, of which there were several during the tests. As the machine, on account of its robust construction, suffered no serious damage during the tests, the experiments will be continued when the controls have been altered. The results will be published in due course."

Regarding the machine itself, comparatively little information is available. The accompanying plan view gives a fair idea of the general arrangement. It will be seen that the main plane has a span of 39 ft. 5 ins., and a maximum chord of 5 ft. 11 ins. tapering to 4 ft. 2½ ins. at the tip. The *ailerons*, which are of the slotted type, have a length of 9 ft. and an area of 13 sq. ft. each. The area of the main plane is 210 sq. ft. On the nose of the machine is placed the front elevator, which has an area of 42 sq. ft., the span being 17 ft. and the chord 2 ft. 9 ins. in the centre.

An interesting feature of this front elevator is that it serves the double purpose of elevator and rudder. To this end it is mounted on a ball-and-socket joint, which allows it to pivot around a lateral axis and also to rock around a longitudinal axis. To reduce the force necessary to turn the plane around the latter axis, small *ailerons* are fitted near the tips. These *ailerons* are connected up with the controls which rock the plane in such a way that, when it is desired to tilt the plane to port, the starboard flap moves down and the port flap up. The controls in the cockpit are of normal type, so as not to present unduly great difficulties in mastering this unusual system.



THE KLEMPERER "DUCK": Plan view of the machine, with main dimensions, etc., shown.

LONDON TERMINAL AERODROME

Monday evening, November 20.

THE "airways" suffered this last week, as did the railways from the persistent visitations of the fog-fiend. For several days, in fact, the continental air routes had their services dislocated and interrupted.

A typical instance of a swift advantage taken of a few hours' improvement in visibility occurred on Wednesday, the 15th. Mr. Robertson, piloting a Daimler 34, was fog-bound at Manchester with five passengers, waiting for a chance to get through to London. Suddenly, soon after 12, a wind that sprang up began to roll away the fog; whereupon Mr. Robertson was quickly in the air and speeding towards London. In the neighbourhood of the Metropolis the visibility was too bad to attempt to reach Croydon; so, doing what it has been found most convenient to do on several occasions lately, Mr. Robertson used the Stag Lane aerodrome, Edgware, as his London air-station, and, setting his five "fares" down there, a fast car soon brought them up into the heart of the city.

The two Fokker monoplanes which—as I mentioned in my last dispatch—were caught on the 12th in a sudden dense fog-belt and were compelled to get down on Epsom Downs, were completely fog-bound until the 17th, when their pilots—Smirnoff and Silliviers—managed in the morning to fly them across to Croydon.

In this regard Capt. Leverton points out that, thanks to the wooden-wing construction of these machines, it was possible to put them straight on to the regular service, once they had reached Croydon, without their having suffered any harm at all through their days of standing out in the fog.

He tells me, incidentally, that some of these wooden wings of the Fokker Amsterdam-London machines have just been taken to pieces and thoroughly examined after a couple of years of regular airway service, and it has been found that there is absolutely nothing the matter with them at all, and that they are as good for flying service as they were on the day they were built.

Fog-compelled inactivities have been relieved by discussions as to the possibility of finding some new location for the London Terminal Aerodrome.

Taking things all round, the feeling is that to make any sudden change might be like jumping out of the frying-pan into the fire. What those who have good words to say of Croydon insist upon is pressure being brought to bear in the right quarter so as to get a railway connection direct, say, from Victoria down on to the edge of the aerodrome, using the siding which already connects the Brighton line with the Aircraft Disposal factory. With this convenience provided, and in full working order when the passenger traffic rush begins again in the spring, it is held that one would have a big job to find a London air-station more suitable than Croydon.

Vagaries of the Fog

TODAY (Monday) the fog has been playing us some odd tricks again. In the early part of the day, for instance, machines were in and out without experiencing any difficulty. Then later on, just as a Handley Page was due in from Paris, some trick of the wind brought a great bank of London smoke and mist drifting across the aerodrome and out to the country beyond. But, thanks to wireless and our other aids, the "Handley" managed to creep in to a perfectly safe landing.

This foggy weather, and other bad conditions atmospherically, such as we have been wrestling with of late, draws particular and renewed attention to a matter I have mentioned in these notes before. That is the admirable confidence with which passengers now come forward to fly, even in weather which one might think would effectually deter them. Fogs, rainstorms, gales of wind—none of these prevent them from being on the spot ready to start, if the flying officials think it is good enough to go; and I think a most encouraging lesson is to be drawn from this alacrity with which "air express" travellers, and more especially business men in haste, now face bad weather in the air without a qualm. It shows, better than anything else could, the growing faith there is in the inherent safety of aerial transport.

THE LONDON-CONTINENTAL SERVICES

FLIGHTS BETWEEN NOVEMBER 12 AND NOVEMBER 18, INCLUSIVE

Route (including certain diverted journeys)	No. of flights*	No. of passengers	No. of flights carrying Mails	No. of flights carrying Goods	No. of journeys completed†	Average flying time	Fastest time made by	Type and (in brackets) Number of each type flying
						h. m		
Croydon–Paris	2	7	2	2	1	2 9	H.P.W.8B G-EBBG (2h. 9m.)	B. (1), H.P.W.8B (1).
Paris–Croydon	4	9	1	4	1‡	3 31	H-P.W8B G-EBBH (3h. 31m.)	B. (1), G. (2), H.P.W.8B. (1).
Croydon–Brussels–Cologne	1	1	1	—	1	4 0	D.H. 34 G-EBBR (4h. 0m.)	D.H. 34 (1).
Cologne–Brussels–Croydon	1	5	1	—	—§	—	—	D.H. 34 (1).
Croydon–Rotterdam ...	2	1	2	2	2	2 29	Fokker H-NABM (2h. 22m.)	F. (2).
Rotterdam–Croydon ...	4	2	2	4	2	3 0½	Fokker H-NABS (3h. 0m.)	F. (4).
Manchester–Croydon–Amsterdam	4‖	20	—	—	4	5 27	D.H 34 G-EBBQ (5h. 27m.)	D.H. 34 (2).
Amsterdam–Croydon–Manchester	4¶	8	1	—	3	5 57	D.H. 34 G-EBBY (5h. 57m.)	D.H. 34 (2).
Total for week ..	22	53	10	12	14			

*** Not including "private" flights.** **† Including certain journeys when stops were made *en route*.**
‡ 3 to Lympne. § Land. Lympne. ‖ Man.–Stg. Lane 2, Croy.–A'dam. 1. ¶ Stg. Lane–Man. 1, Croy.–Man. 1.

Av. = Avro. B. = Breguet. Br. = Bristol. Bt. = B.A.T. D.H.4 = De Havilland 4, D.H.9 (etc.). F. = Fokker. Fa. = Farman F.50. G. = Goliath Farman. H.P. = Handley Page. M. = Martinsyde. Sp. = Spad. Vi. = Vickers Vimy. Vu. = Vickers Vulcan. **W. = Westland.**

The following is a list of firms running services between London and Paris, Brussels, etc., etc.:—Co. des Grandes Expresses Aériennes; Daimler Hire, Ltd.; Handley Page Transport, Ltd.; Instone Air Line; Koninklijkie Luchtvaart Maatschappij; Messageries Aériennes.

Incidental Flying.—Mr. Perry out testing a Sopwith Snipe, and Capt. Stoken testing a similar machine and two Avros for the Aircraft Disposal Co. at Croydon on 17th and 18th.

THEORY OF THE SLOTTED WING*

LECTURE by A. BETZ, GÖTTINGEN.

THROUGH the intensive study of all technical aviation problems during the war, the most important aeroplane parts, especially the wing, were so thoroughly tested as to create the impression that no further substantial improvement was possible. The characteristics of the different wing sections were sufficiently known to enable one to select the most suitable section for almost any purpose.

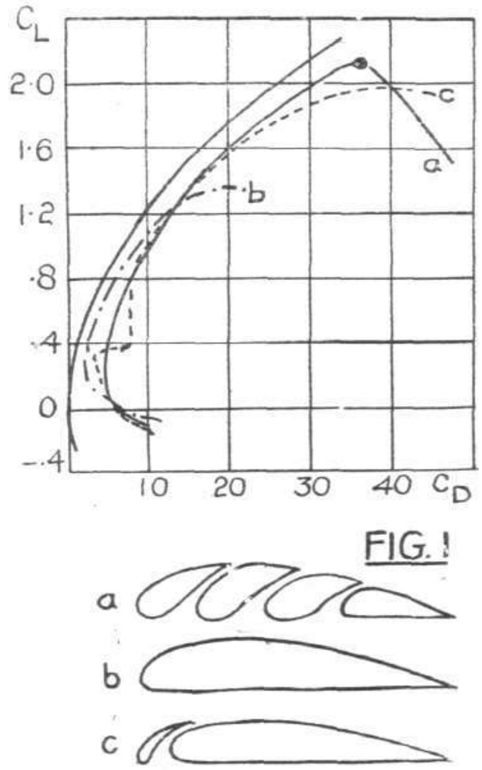
Then the discovery by Lachmann and Handley Page suddenly revealed entirely new possibilities and the wing section again became a rich field of problems. As probably you all know, this discovery consisted in making one or more slots in the wing section (Fig. 1). In this way it is possible to use the wing at higher angles of attack, and thus considerably increase the lift. The lift-drag ratio, however, seems to be no better in general than for ordinary wing sections. The advantage lies principally in the ability to vary the coefficient of lift, and hence the speed, within considerably wider limits. Hereby, the difficulties of taking off and landing are diminished and greater flight speeds made possible. Our knowledge of the behaviour of such slotted wings under the most diverse conditions is, unfortunately, very limited, and there is still much work to do before we shall have carried our investigations so far as to be able to choose, from the many possible modifications, the one best adapted for any given purpose.

The question of the most practical importance is what must be done in order that with an aeroplane we can obtain the best possible lift-drag ratio if the lift-coefficient is low, and, in addition, be able to reach, by easily made changes, a considerably higher coefficient of lift where the lift-drag ratio does not need to be especially good. The former condition would be used in ordinary horizontal flight, and the latter in taking off or in landing. The purely experimental solution of all the problems connected with these new wing sections is rendered very difficult by the large number of possible modifications. The most diverse cross-sections may be given the component parts of the wing and their relative size may be varied, thus bringing the slot nearer either the leading or trailing edge. Furthermore, the relative position of the parts and the width of the intervening slot may be varied. Lastly, there is the possibility of varying the number of the component wing-parts by the introduction of one or more slots. Although, for structural reasons, many forms do not come into practical consideration, the number of possibilities is still very large.

The experimental work will be considerably simplified and rendered more productive of results if we succeed in obtaining at least an approximate idea of what takes place. We are still, however, far from being able to give a complete theoretical explanation of the phenomena of slotted wings. Nevertheless, we can contribute something towards the explanation of the unusual increase of the lift-coefficient. I do not wish, however, to create the impression that what I am about to say is conclusive. I wish rather to bring the matter up for discussion, in the hope that still other view-points may be presented which will help to clarify the problem.

We must first consider the question as to how it happens that, with a given wing section, the lift-coefficient cannot be increased at will. In order to answer this fundamental question, we must consider more carefully the process by which lift is generated. It is known that lift is produced by the greater velocity, and consequently smaller pressure, of the air on the upper side of the wing than on the lower (Fig. 2). This difference must vanish at the trailing edge, around which the pressures can become equalised. The difficulty lies in the fact that a strong suction must be generated on the upper side, only to vanish again at the trailing edge. From the point of least pressure on, the kinetic energy of the air must therefore be transformed into pressure by a gradual increase in the cross-section of the tubes of flow. There accordingly takes place, on the rear portion of the upper side, a phenomenon very similar to the flow through a widening tube.

Now, it is known that such a flow, in which kinetic energy is transformed into pressure, remains stable only for a very gradual increase in the size of the cross-section. If the diameter increases too rapidly, the air does not continue to flow smoothly along the wall, but separates from it and goes its own way as a free jet, and the increased pressure is not obtained. If we increase the angle of attack of an aeroplane, the cross-sections of the tubes of flow on the suction-side are increased; and if a certain figure is exceeded, the air no longer flows along the upper surface of the wing, but is torn off, as it is expressed. This phenomenon is shown by Figs. 3 and 4. (The photographs were made by Dr. Heis and published in Prof. Prandtl's report on the Göttingen Aerodynamic Laboratory, in the *Year-Book of the Air Traffic Association*, 1912–1913.) The first picture shows a wing having a normal angle of attack. The flow conforms quite well to the top of the wing, and is not seriously affected by the small vortices which cover the wing. With larger wings and greater velocities the vortices are probably still smaller. The second picture shows the same wing at a somewhat greater angle of attack, in which case the fluid no longer follows the top of the wing.



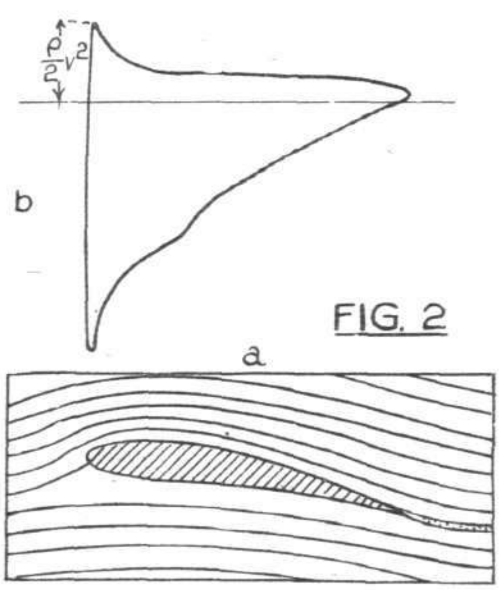


Fig. 1.—Polars of an ordinary wing and of two slotted wings.
Fig. 2.—Flow around a wing section (a), and, (b), corresponding pressure distribution.

* Reprint from *Berichte und Abhandlungen der Wissenschaftlichen Gesellschaft für Luftfahrt* (supplement to *Zeitschrift für Flugtechnik und Motorluftschiffahrt*), No. 6, January, 1922 (Technical Note No. 100 of the American N.A.C.A.).

Involuntarily we now ask how it happens that the air does not separate on even a moderate increase in the diameter of the cross-section. The explanation lies in the viscosity of the air or, in most cases, more correctly, in an apparent viscosity, which in turbulent phenomena is conditioned by the turbulence itself. The case may be pictured qualitatively as follows :—The fluid has a tendency, on account of its inertia, to flow straight ahead, instead of following the curved surface, but then there must exist, between it and the surface of the wing, a quiet or an eddying "dead-water" region. This "dead water" is now carried along by friction (or the effect of viscosity), and must be constantly replaced (Fig. 4). Now, when the viscosity is so great that, in a given time, more fluid is carried away than can flow in, the "dead water" therefore be assumed that the influence of the curvature of the flow plays a rôle of some importance with a given wing section with a moderately large camber, but nothing further is thereby gained than would be gained by a larger camber. The extraordinarily large increase in the maximum lift cannot therefore be thus explained.

The following consideration may be of more importance. The front wing lies in a region of increased velocity. Now, since the force of the air is proportional to the square of the velocity, it is evident that the lift on the front wing is thereby considerably increased. This argument has but one exception, namely, that the reverse is true of the rear wing, so that for the combination of the two wings the two effects neutralise each other. In calculating the relations for an

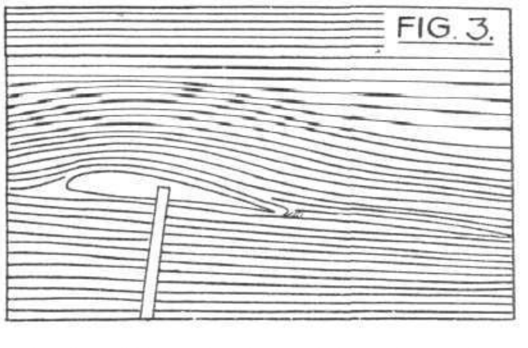


Fig. 3.—Flow about a wing section at an angle of attack of 8 degrees.

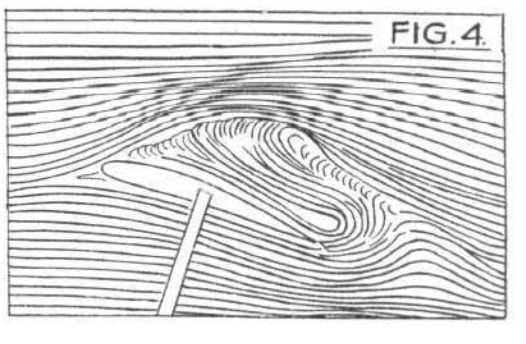


Fig. 4.—Flow about a wing section at an angle of attack of 19 degrees.

disappears and the flow follows the surface of the wing (Fig. 3).

Such are the general outlines of the phenomena which produce lift and which also limit its magnitude. Unfortunately, these phenomena cannot be treated quantitatively by theoretical methods. We must therefore content ourselves with qualitative illustrations, and will now endeavour to explain, on this basis, the action of the slotted wing.

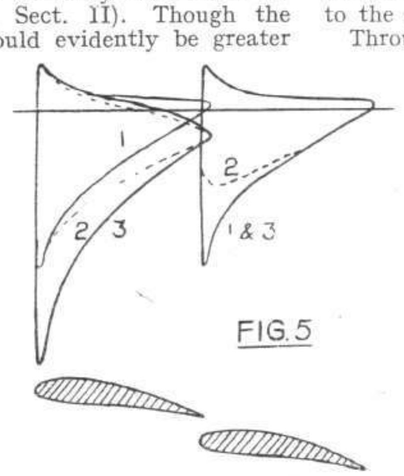
For the sake of simplicity, we will assume that there is only one slot. Such a wing section may be imagined as a biplane with a very great positive stagger and a very small distance between the wings. Some justification for this conception proceeds from the fact that, even with an ordinary biplane, the maximum lift is increased by a positive stagger. According to biplane measurements published by myself in the fourth volume of "Zeitschrift für Flugtechnik und Motorluftschiffahrt," the maximum C_L without stagger was 100, with a positive stagger of 30° it was 110 and for one wing alone it was 106. Similar results were also obtained in England (Technical Report of the Advisory Committee for Aeronautics, 1915–16, Rep. 196, Sect. II). Though the differences are not great, they would evidently be greater

unstaggered biplane we even obtain a smaller maximum lift than for the two wings alone, and this result is confirmed by experiments. The relations are, however, somewhat changed by staggering. We must go into this more thoroughly.

We will first consider the arrangement with two wings of about the same size, in which the relations stand out the clearest. The front wing, taken alone, would have a pressure distribution somewhat as shown by the fine line on the left of Fig. 5. Now, if we bring the rear wing, which has about the same pressure distribution by itself, into proximity with the front wing, the trailing edge of the latter will lie in a region of great velocity, and correspondingly small pressure, produced by the rear wing. The leading edge of the front wing, on account of its greater distance from the rear wing, lies in air that is much less disturbed, and consequently in a region of nearly normal pressure. The leading edge of the front wing is, accordingly, not much affected by the pressure on the rear wing, while the pressure on the trailing edge of the front wing is diminished. We will therefore obtain, for the front wing, a lift distribution corresponding somewhat to the dash curve in Fig. 5.

Through this modification of the pressure curve, the pressure

Fig. 5.—Change in pressure distribution due to mutual influence of both wing sections. 1. Undisturbed pressure distribution. 2. Disturbed pressure distribution with unchanged angle of attack. 3. Pressure distribution with increased angle of attack. For rear wing curves 1 and 3 coincide.



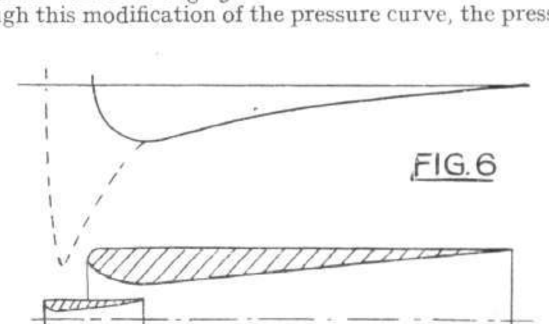


Fig. 6.—Double Venturi tube with corresponding pressure distribution. Pressure in outer tube shown in plain line, in inner tube in dash line.

if the stagger were increased and the interval between the wings diminished.

We will first consider only the front wing, and discuss how its characteristics are affected by the rear wing. From the theory of the biplane, we know that the flow is here obliquely upward. This affects the lift-drag ratio, but not the maximum coefficient of lift, which here alone interests us. We also know that, at this point, the flow is obliquely upwards. This has about the same effect as increasing the wing camber. By increasing the latter the maximum lift may actually be increased, though only to a very limited degree and at the expense of the lift-drag ratio. The rear wing is similarly affected by the curvature effect. It may

increase on the suction (upper) side becomes much flatter. On the other hand, we know that the limit of the lift is determined by the steepness of the pressure curve. It is therefore evident that we may now further increase the angle of attack until the inclination of the pressure curve again reaches its limit value (heavy line in Fig. 5). Since the velocity has become greater everywhere, the pressure curve may climb steeper than before.

As is obvious, the lift, which is represented by the area enclosed by this curve, has become considerably greater.

Let us now turn our attention to the rear wing. Here we find corresponding phenomena. The front wing produces on the leading edge of the rear wing a decrease in velocity and

a consequent decrease in the pressure diminution or suction. The trailing edge remains practically unaffected. Thus we obtain here, near the leading edge and mainly on top, a decrease in pressure. The strong suction (or negative pressure) is diminished, so that here also there is a flatter pressure increase, as shown by the dash line. By increasing the angle of attack we return approximately to the original curve, while the lift of the rear wing remains practically unchanged. Hence, in this combination the two wings produce a greater maximum lift than when separate, the gain being principally on the front wing.

The phenomena described will perhaps be more intelligible if we take for comparison the perfectly analogous phenomena of a simple and a compound Venturi tube. Fig. 6 shows a double Venturi tube, such as is often used on aeroplanes for measuring air speed. If we first imagine the small inside tube removed, we have a simple Venturi tube. The air flows through the constricted section with increased velocity and correspondingly diminished pressure. In the diverging cone behind it the kinetic energy is again largely transformed into pressure, so that at the rear end the external and internal pressures are again equal. Exactly the same causes which limit the lift in a wing here make it impossible to obtain, by narrowing the throat, a pressure diminution of any desired value. In this case, however, it has long been known how to increase the suction by a suitable combination of tubes.

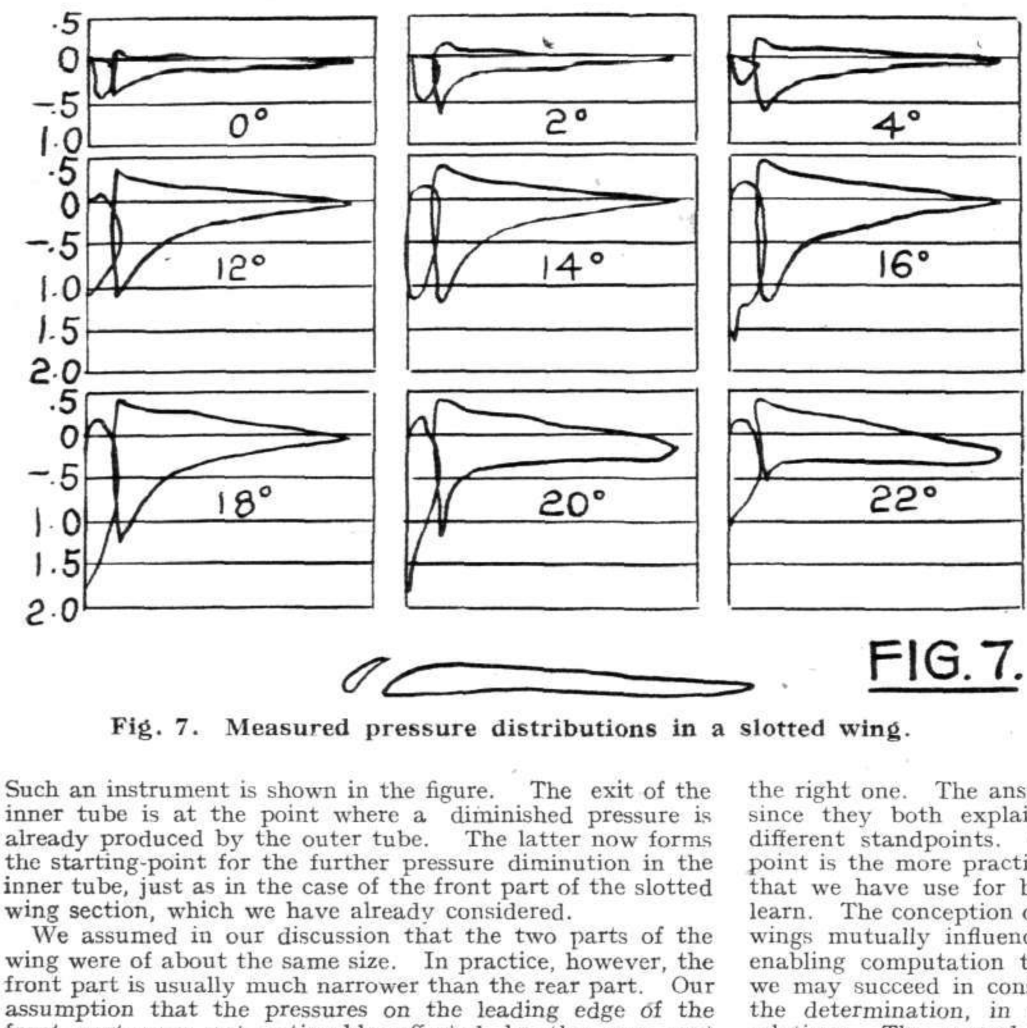


FIG. 7.

Fig. 7. Measured pressure distributions in a slotted wing.

Such an instrument is shown in the figure. The exit of the inner tube is at the point where a diminished pressure is already produced by the outer tube. The latter now forms the starting-point for the further pressure diminution in the inner tube, just as in the case of the front part of the slotted wing section, which we have already considered.

We assumed in our discussion that the two parts of the wing were of about the same size. In practice, however, the front part is usually much narrower than the rear part. Our assumption that the pressures on the leading edge of the front part were not noticeably affected by the rear part no longer holds true. Here the whole of the front section lies in a field of increased velocity, and is thus able to produce a greater lift, since the lift is proportional to the square of the velocity. For the rear section, however, our previous remarks hold good. The disturbance due to the front section is felt principally on the leading edge, which therefore has approximately its normal lift. Accordingly, we even here obtain increased lift for the whole combination.

That the actual pressure distribution is approximately as described follows from the data published by Handley Page in *Engineering*, March 4, 1921. These data are given in Fig. 7. For small angles of attack the rear section shows about normal lift distribution. The auxiliary wing in front gives only a small lift, since its angle of attack is much too small. Only from 12° up does the lift of the auxiliary wing show any considerable increase, while the pressure distribution of the main wing remains almost the same. The increased suction on the trailing edge of the auxiliary wing is also evident. At about 20° the flow separates from the main wing and the lift of the auxiliary wing diminishes.

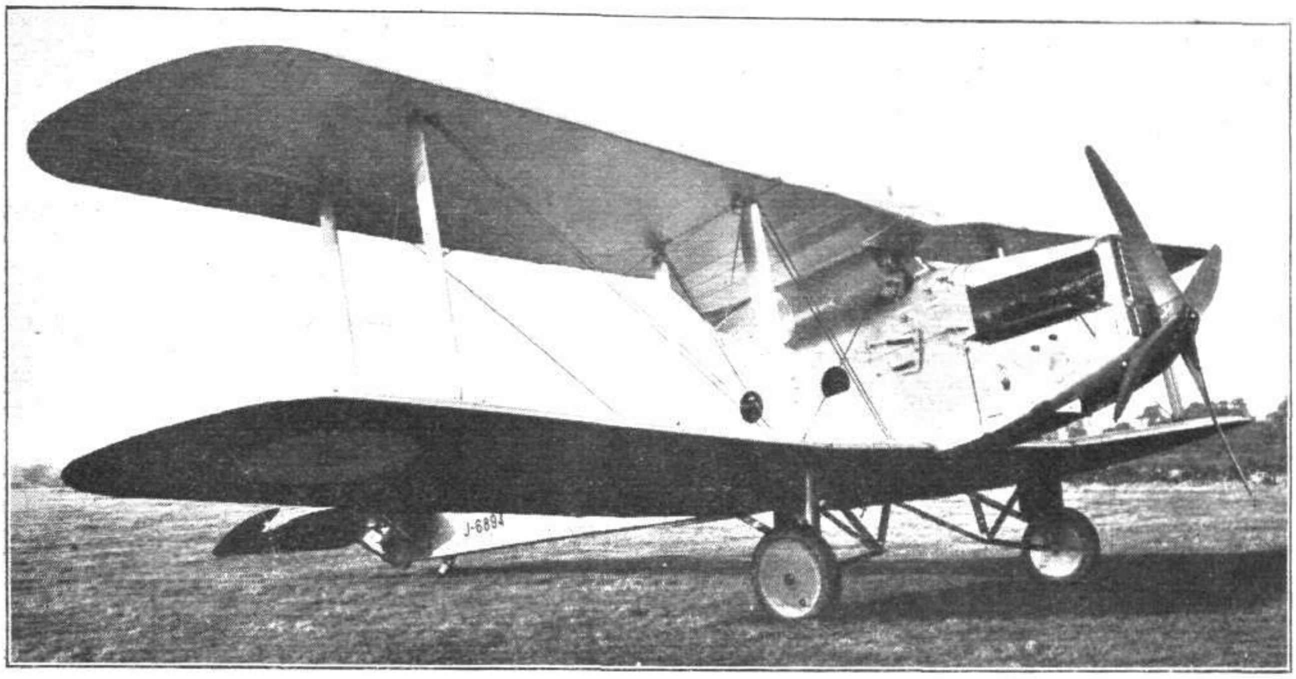
The above conception of the phenomena renders the occurrence of an increased lift-coefficient somewhat more comprehensible, and even offers the prospect of making it possible to compute the relations. On the other hand, the following consideration may be presented. If the slot is continuously narrowed, the arguments pointing to a higher maximum lift continue to hold good, but the phenomena vanish when the slot is closed altogether. This was to be expected from the first, since the wing is transformed by closing the slot into one of a practically normal shape. In any event, a slot of a certain minimum width is essential. Since the theory just presented says nothing about this, the phenomena must also be considered from a different standpoint.

In explaining the phenomena of lift production, I called attention to the fact that the clinging of the air stream to, or its separation from, the upper surface of the wing depends on whether the dead air is carried off fast enough. When we consider this phenomenon on the rear section of a slotted wing, it is obvious that the work (which may be called pump-work or suction) must be performed at the expense of the kinetic energy of the thin air stream flowing through the slot. If the latter is made too narrow, the ribbon of air finally becomes so thin that its kinetic energy no longer holds out to the trailing edge of the rear section, but is itself transformed into dead air by mixing with the dead air above and below it. When considered from this standpoint the phenomena of the slotted wing appear in quite another light. We can now think of this wing section as an entity derived from an ordinary wing section by connecting its upper and lower surfaces by slots, which is, in fact, the conventional conception. The slots convey new energy to the marginal layer of air retarded by friction on top of the wing, thereby increasing its velocity and thus preventing the accumulation of dead air. The air stream flowing out of the slot acts like the jet from a syringe and reinforces the air stream on top of the wing in carrying away the dead air. Since the production of lift depends on the efficiency of this pump-work and the maximum lift is conditioned by the limited possibility of carrying off the dead air, it is apparent that any increase in the pumping efficiency increases the maximum lift.

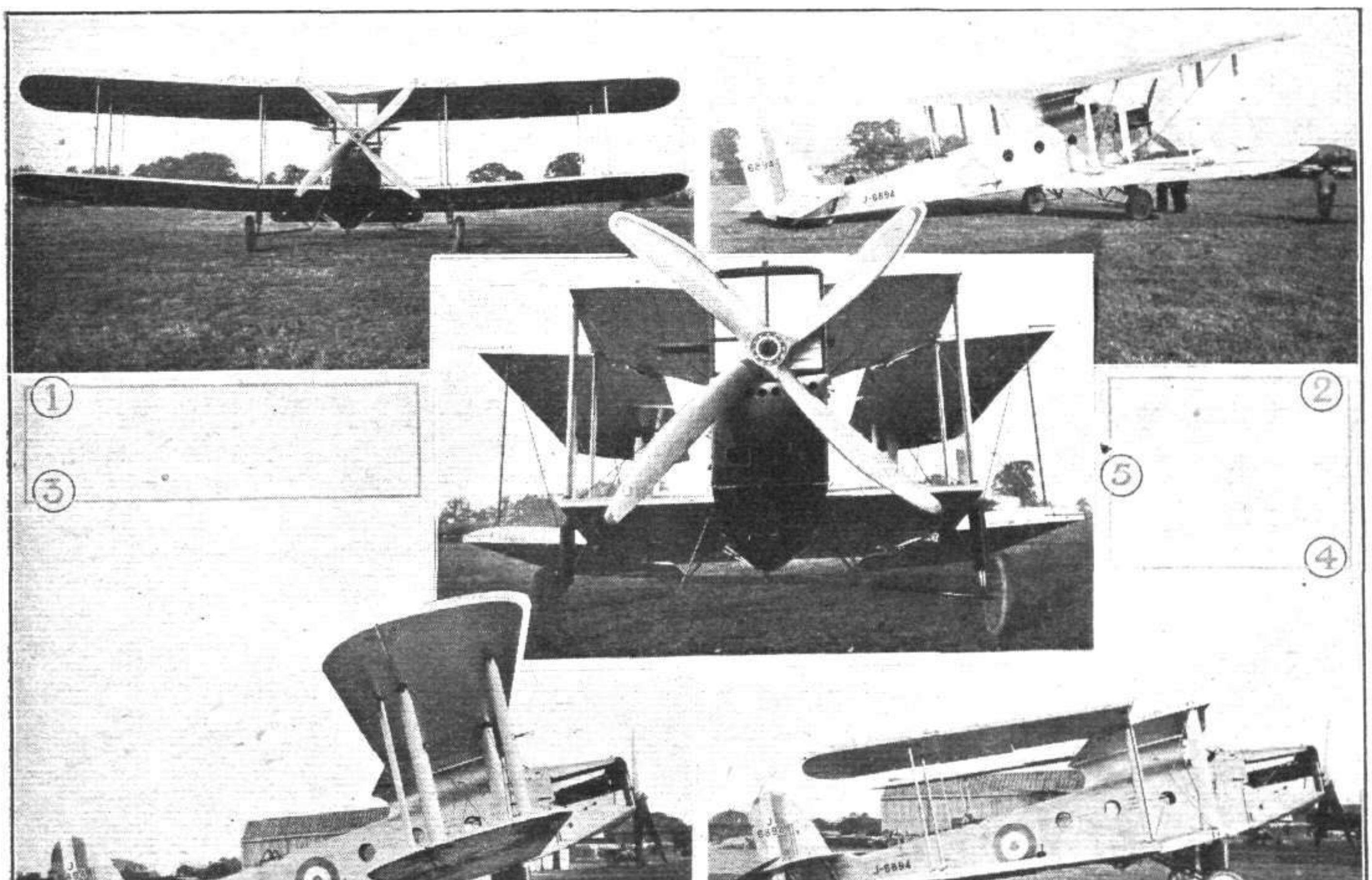
We are now inclined to ask which of these two theories is the right one. The answer is that both are equally correct, since they both explain the same phenomena, but from different standpoints. We should rather ask which view-point is the more practical. To this question I would reply that we have use for both, according to what we wish to learn. The conception of the slotted wing as a biplane whose wings mutually influence each other has the advantage of enabling computation to a certain extent. With its help, we may succeed in constructing formulæ which will enable the determination, in some measure, of the quantitative relations. The second view-point is essential when it is desired to form an idea of the requisite width of the slot. I would add a word of warning against too great optimism. The relations are much more complicated here than, for example, in the theory of the monoplane or biplane. Much work must still be done before these theories are developed into practical rules. With the limited means now available, much time will be required for this work. The immediate task is to determine whether the theories just presented really explain the essential features of the phenomena, or whether other circumstances of decisive influence will come in. This cannot be conclusively determined from the experimental data now available. If the theory, however, agrees with the facts, this is already a great gain, even though we do not succeed in working out convenient computation formulæ. We then know, at least, what the essentials are for obtaining the right shapes, and can thus save ourselves much useless work.

THE NEW DE HAVILLAND BOMBER "DERBY"

Type D.H.27



THE NEW DE HAVILLAND BOMBER, TYPE D.H.27, "DERBY": Three-quarter front view.



THE NEW DE HAVILLAND BOMBER: Known as the D.H.27 "Derby," this Machine is fitted with a Rolls-Royce "Condor" engine. The Air Ministry has sanctioned publication of these photographs, but no details may be given. 1. Front view. 2. Three-quarter rear view. 3. Side view with wings extended. 4. Side view with wings folded. 5. Close-up view of machine with wings folded.

THE CO-RELATION OF MODEL AND FULL-SCALE WORK

"MODEL tests are capable of a wide usefulness in aeronautical engineering if the model work can be satisfactorily co-related with the full scale." The "if" in above sentence formed the subject of an interesting paper read by R. McKinnon Wood before the Royal Aeronautical Society on November 16, 1922. The lecturer pointed out that unless we can establish some relation between the model work and the full scale, the former must be of very uncertain value. We may, he said, endeavour to do this theoretically or experimentally, and proceeded to outline the theoretical method first.

After defining the three physical properties of air (fluidity, viscosity, and compressibility), the lecturer stated that only the first two were of importance in aeronautical work, as, except in the cases of shells, bombs, and airscrew blades, the pressures caused by the speeds attained by aircraft were not large enough to cause important changes in density. The lecturer then gave the equation expressing the law of dynamic similarity, pointing out that this law does not indicate the manner in which the pressure may vary if the quantity $vl\rho/\mu$ is not the same for the model as for the full-size machine. In order to conform to this law it would be necessary to test a one-tenth scale model at ten times the speed of the full scale machine, and not only would this require great power expenditure, but the pressures attained at such speeds would be such as to cause compressibility of the air.

"This Law of Dynamic Similarity," the lecturer continued, "cannot, therefore, be conformed to in the wind channel as we use it. But there is another possible method by which models might be tested at the full scale value of $vl\rho/\mu$. If a model to a scale of 1/10 be tested in a channel built inside a strong steel chamber filled with air at 10 atmospheres pressure at atmospheric temperature, the value of $vl\rho/\mu$ is the same as that of the full scale at the same speed. The forces to be measured will be ten times as great per unit area as on the full scale, and this introduces difficulties in supporting the model which would make it desirable to work at lower velocities with a compensating increase in density and so reduce the pressures to a convenient value. I believe that the not inconsiderable difficulties which would arise in constructing a high-pressure channel and designing suitable balances can be overcome. The cost of this method of experimenting would be greater than that of an atmospheric channel, but still much less than that of full-scale work."

The lecturer then started the discussion of the nature of viscous flow by considering the flow past a body consisting only of a surface moving in its own plane, and indicated the manner in which the layer in actual contact with the body is at rest relative to the surface, while the velocity increases as we pass outwards from it. The resistance of thin smooth flat plates edge-on to the wind has been found by experiment to follow the law $k = (vl\rho/\mu)^{-0.15}$ over a wide range.

For the more practical case of bodies having a certain thickness, the lecturer pointed out that the total drag is composed of two parts: (1) the resultant of the pressure normal to its surface, and (2) the resultant tangential to its surface. The effect of viscosity is two-fold: (1) it modifies the form of the flow so that the normal pressures have a resultant, and (2) tangential forces are exerted on the body. The resultant drag is composed of these two parts in proportions depending on the shape of the body. The streamlines do not follow the body to the extreme tail, but break away at a greater or smaller distance, according to the fineness of the body, and enclose a "dead water" region. The lecturer here showed a slide of a curve obtained in a wind channel, showing the scale effect on a strut. The curve indicated considerable scale effect at low values of $vl\rho/\mu$, but at high values the scale effect was quite small, and from this the lecturer concluded that although tests on small models at low speeds may be of little value, it may be possible to carry out model tests at sufficiently high values of vl to give a close approximation to the full scale.

Turning his attention to unsymmetrical bodies, the lecturer pointed out that such bodies experience both drag and a cross-wind force, or lift, and that the principle of conservation of energy leads to Bernoulli's equation connecting pressure and velocity, $p + \frac{1}{2}\rho v^2 = \text{const.}$, except to the extent to which energy is degraded into eddies and heat by the action of the viscous forces. This degradation is small at high values of L/D, and Bernoulli's equation is closely true for the streamlines which do not pass very close to the surface of a wing. In the language of hydrodynamics, the flow is composed of a translation (or linear motion) and a circulation around the wing. Diagrams were then shown of the form of flow which should theoretically exist past a wing moving in a fluid having no viscosity, the span being assumed infinite. A second slide showed the fluid circulating around the wing, while on a third the two motions were shown superimposed.

"It seems," the lecturer continued, "that a good approximation to the lift of a wing might be obtained by a calculation by non-viscous theory if we could determine what governs the strength of the circulation which is produced through viscosity; and in relation to scale effect the question of interest is whether this depends upon the magnitude of the viscosity or only upon the existence of viscosity. In the latter case we have a reason for expecting no scale effect upon lift."

After referring briefly to the work of Joukowsky, the lecturer made reference to German work on the subject, notably that of Prandtl, about whom the lecturer said: "Starting from the two-dimensional viscous flow round a wing of given section and of infinite aspect ratio, Prandtl has deduced valuable theorems about the three-dimensional flow round a wing of finite aspect ratio, so that from a test of a wing of any one aspect ratio the characteristics of wings of the same section and of other aspect ratios may be calculated. Other theorems deal with multiplane systems, with the influence of the proximity of the ground and of the walls of a wind channel.

"The layer of fluid in contact with a body is at rest relative to the body, and the velocity gradient close to the body is steep in comparison with gradients elsewhere in the fluid. Measurements of velocity in air flowing along a surface show the very small distance at which there is a sensible reduction of velocity in comparison with the length of surface traversed. The tangential stresses in the fluid due to viscosity are, therefore, relatively great close to the surface of the body, and while viscosity may be responsible for the lift by producing a circulation, the flow at a little distance from the wing may be calculable by arguments which ignore the viscosity if they include the circulation to which it gives rise. We may summarise the argument by saying that the action of viscosity is concentrated towards the surface of the body. This constitutes the justification of Prandtl's application of non-viscous hydrodynamics to aeronautics. Another well-known application of non-viscous hydrodynamics is the theorem of Froude relating to screw propulsion, which has been subsequently combined with the Aerofoil Theory of Airscrews, most successfully, I think, by H. Glauert's recent development of Prandtl's work.

"I can only give here a brief outline of Prandtl's work. Consider a finite wing experiencing a uniform lift along its span. There will be a uniform circulation along the span which cannot cease at the tip, as by a theorem of hydrodynamics vortices cannot have a free end. A vortex must, therefore, trail from each tip. (In practice the lift will not be uniform to the tips, and the wing will, therefore, trail a sheet of vortices, the strength of the vortices from each portion corresponding to the fall of lift.) Comparing the finite wing with a hypothetical wing of infinite span, it will be seen that the trailing vortex system gives a downwash trend to the stream within the span and an upward trend beyond the tips. Whereas the flow before and behind the infinite wing is symmetrical (on the basis of non-viscous flow with circulation), the downwash behind the finite wing is greater than the upwash ahead, and the air at the wing has a downward trend. The wing moves in a downwash of its own producing.

"This downwash at the wing can be easily calculated with sufficient accuracy. The method of estimating the lift and drag of the finite wing from those of the infinite wing is shown by the table in which ϵ represents the downwash at the wing:—

Aspect Ratio.	Infinite.	Finite.
Lift coefficient	k_L	k_L
Incidence	α	$\alpha + \epsilon$
Drag coefficient	k_D	$k_D + \epsilon k_L$

"This shows the incidence at which the two wings give the same lift and the drag coefficients which then obtain. Infinite aspect ratio is the datum of the theory, but, of course, in practice the datum will be a test upon a wing of some finite aspect ratio.

"Prandtl calls this increment of the drag at given lift by the trailing vortex system the 'induced drag,' and the drag of the wing of infinite aspect ratio and of the same section he calls the 'profile drag.' If there is no scale effect on lift, we may expect scale effect on drag to be confined to the 'profile drag,' and the variation to be greater in proportion to the whole drag at the smaller angles of incidence.

"These circulation theorems have received considerable

experimental verification. They are found to give with good accuracy the effects of change of aspect ratio and the direction of flow at points not too close to the wing. Unfortunately, the most useful calculation of direction of flow, the downwash at the usual position for the tailplane, is complicated by the rolling up of the vortex sheet, and has not so far been accurately made.

"In so far as reliance might be placed upon this form of calculation, it is clear that a solution obtained by a model experiment should be independent of scale, and a class of problems exist in which wind channel results apply without doubt to the full scale. As an illustration there should be no scale effect upon the relation between lift and downwash, whatever scale effect may exist between lift, drag and incidence.

"To summarise the conclusions of the theoretical discussion :—

"(1) There is a law of dynamic similarity to which we do not conform in our model experiments.

"(2) Until the mathematical theory of the flow of a viscous fluid is further advanced we cannot arrive at a precise or certain theory of scale effect when this law is violated.

"(3) Our experience leads us to believe that by experimenting with models to the larger scales which we use we obtain a good approximation to the full-scale conditions.

"(4) We have some reason to believe that scale effect upon lift will be less than upon drag (until the stalling angle is approached).

"(5) Certain applications of non-viscous theory to aeronautics are justifiable, and these are independent of scale."

Having thus outlined the theoretical method, the lecturer proceeded to indicate the conditions under which model tests in wind tunnels are made. As these will already be well known to readers of FLIGHT, we can confine ourselves to certain aspects which are not, perhaps, so generally appreciated.

"The walls of the channel," the lecturer said, "exercise a constraint upon the flow, and influence the results to an extent which depends upon the relative size of the model and the magnitude of the air forces. The Froude propulsion theorems have been extended to provide a theory for correcting tests of airscrews in a channel, and the work of Prandtl provides a theory for correcting tests of wings. The latter deserves some discussion here.

"If the walls of the channel were optical mirrors, series of images of the model would be seen. The model in the channel is more or less aerodynamically equivalent to a model flying in formation with these images. By the circulation aerofoil theory the influence of these images on the model may be calculated. The corrections are :—

$$\Delta\alpha = 16\ Sk_L/h^2$$

$$\Delta k_D = 0\cdot27\ Sk_L{}^2/h^2$$

where S is lifting area of model and h the breadth of a square channel.

"The following table shows the percentage correction applicable to the lift/drag ratio of biplane wings 6 in. × 36 in. of R.A.F. 15 section, tested in a 7 ft. wide channel and in a 4 ft. channel.

Lift coefficient ..	0·15	0·275	0·40	0·475
Seven-foot channel	4	7	9	7 per cent.
Four-foot channel ..	12	21	27	21 per cent.

"Such a model would probably never be tested in a four-foot channel, and some doubt may be felt as to the reliability of a correction of such magnitude ; but the correction for the seven-foot channel is large enough to receive attention, and I think that the theory may be relied upon for corrections of this size, as it has been found to bring tests of a 6 in. × 36 in. monoplane in four and seven-foot channels into good agreement.

"The interference of the channel walls increases the rate of change of lift with incidence and reduces the stalling angle ; reduces the drag by an amount proportional to the lift, giving the drag curve a less steep slope ; it also reduces the downwash and so increases the stability and makes the model relatively 'nose-heavy.'

"We have also to recognise that the model tests which we make are generally tests upon isolated components which must be applied to complete aircraft with caution. The completest model tests which we are accustomed to use do not represent the aircraft flying under its own power. The action of the airscrew slipstream upon the tail unit is important and highly complex, and I should hesitate to estimate it. The mutual interference of parts is often large, especially when the parts are of low resistance form."

Regarding full-scale experiments, the lecturer pointed out that one source of error was the unknown vertical currents in the atmosphere, which might introduce serious errors. The experimental investigation of scale effect was dealt with next, but as our space is limited and this aspect of the problem will be fairly well known from published Reports and Memoranda, we must pass it over.

"These results," the lecturer continued, "are typical of others, from which, in my opinion, we may conclude that carefully-conducted wind channel tests at sufficiently large values of VL give a very good prediction of full-scale performance for the most common type of aeroplane, the thin wing biplane ; but we must be cautious of generalising this conclusion."

Reference was then made to the way in which deeply-cambered aerofoils, such as R.A.F. 19, may show higher lift coefficients at low values of vl than at high values ; in other words, the scale effect "goes the wrong way." The lecturer pointed out in this connection that one should not from this fact form the conclusion that slotted wings will behave in a similar manner. "Moderately thick wings," he said, "such as section 64, do not exhibit this scale effect, and thicker wings than 64 may attain the lift given by the model."

"*Conclusion.*—I have endeavoured in this paper to give a survey of the subject at the risk of some loss of lucidity in the attempt to cover a wide field. Two factors in the relation between wind channel tests and the full scale seemed to require discussion : the differences between the conditions of the wind channel and those of free flight, and the possible results of the failure to conform to the Law of Dynamic Similarity. I have dealt at some length with theories which I think help towards an understanding of the use of model tests, and this has prevented me from examining the experimental evidence at all extensively. Ultimately, we may achieve a complete theory of viscous flow ; but this is far off, and at present theory does not take us far. In the meantime we must be prepared to find departures of the full scale from predictions based upon the model ; but as the experimental evidence has accumulated, the use of model tests has acquired a basis of considerable certainty. Scale effect is seen to be evanescent upon most of the forms which we wish to use, and it is practicable to conduct the model tests upon a scale sufficient to give accurate predictions. On the other hand, we wish at times to use forms, typified by R.A.F. 19 wing, of which this cannot be said, and I am anxious to see a compressed air wind channel built as the most rapid means of advancing the investigation of these shapes ; but in any case the comparative full scale and model work should be vigorously continued by the most accurate means we can devise.

"Although the relation between model and full scale is not fully understood, and the wind channel is not infallible, it is, I think, generally agreed that it has a wide sphere of usefulness, is a method of good reliability, and valuable both as an aid to design and as a means of rapid experimental investigation."

Low Flying over Leeds

THE first prosecution at Leeds under the Air Navigation Act of 1920 took place on November 14, when Derrick A. Shefferson, pilot, and the De Havilland Co. were summoned for flying an aeroplane lower than 4,000 ft. above the city. The aeroplane was being used to take photographs from the air on the day of the offence. The pilot explained that his engine failed and he had to descend on Woodhouse Moor. As he did so, he saw a nurse and baby sitting on the grass. He swerved in order to miss them, and in doing so his machine caught some trees. The aircraft company were fined £25 and 10 guineas costs, and the pilot was fined 40s.

Mr. Tilghman Richards Disengaged

WE learn that Mr. G. Tilghman Richards is shortly severing his connection with Martinsyde, Ltd., of Woking, whose general manager he has been for more than a year, and that he would like to return to the aircraft industry. Mr. Tilghman Richards received his early training in the motor-car industry, but became attracted by aviation quite early, joining the late Mr. Cedric Lee in his experiments on the circular monoplane at Shoreham. In 1914 Mr. Richards was commissioned lieutenant in the R.N.A.S., and was appointed inspector of naval aircraft at Beardmore's. In 1915 he joined Beardmore's as designer and assistant manager of the aviation department, which position he held until the closing down of Beardmore's aircraft department in 1921. Mr. Tilghman Richards has, although it may not be generally known, had very considerable experience with gliders and gliding, the "circular" plane being tried in model and full-sized glider form before and in between flights with the full-size power-driven machines.

PROF. WILLIAM NEWELL'S ACCIDENT.

WE regret to learn that the late Prof. William Newell, who met his death during a parachute descent in Denmark on October 24, has left his wife and his five boys, aged from 1 to 15 years, totally unprovided for. It is felt that an effort should be made to help them in their distress, and a fund has been opened for this purpose. We trust our readers will assist in this direction by sending subscriptions to one or other of the following :—

THE REVD. PREBENDARY F. W. JOYCE,
The Vicarage, Harrow.

MESSRS. E. R. CALTHROP'S AERIAL PATENTS, LTD.,
423 and 423A, Edgware Road, London, W. 2.

MESSRS. C. G. SPENCER AND SONS,
56A, Highbury Grove, London, N. 5.

From the report on the searching investigations as to the cause of the accident, which we have received from Mr. Calthrop, it would seem that this regrettable accident is clearly a case of familiarity breeding contempt on the part of the unfortunate parachutist. From the evidence sent to us it appears that Prof. Newell neglected to see that the reaction tapes had been connected up with the rigging tapes by the standard "breaking cords," with the result that the rigging tapes were not extended and the pull of his falling weight came at once upon the periphery of the parachute body. Thus the latter was pulled out lopsidedly, so that the launching ring got jammed and wedged the upper part of the silk body in the container.

Although the pilot, Mr. Johansen, managed to get low down over the water, enabling Newell to release himself when at a height of about 60 ft., and drop into the water, Newell was unable to swim for more than 20 yards or so, and eventually, although help reached him within six minutes, he succumbed to the extreme cold, and exhaustion.

It is certainly unfortunate—not to say inexplicable—that the late Prof. Newell, with his vast experience and knowledge of parachuting, should have neglected certain vital operations in the folding, etc., of the parachute, when he must have known the great risk he was running in consequence. Our fullest sympathy is extended to Mrs. Newell—herself a parachutist and therefore able to understand the facts—and her family.

SIDE-WINDS

MR. H. SPENCER NAYLOR, Managing Director of Naylor Brothers (London), Ltd., varnish and paint manufacturers, of Slough, Bucks., has been elected Chairman of the London Association of the National Federation of Associated Paint, Colour and Varnish Manufacturers of the United Kingdom.

- - -

WE are not surprised to hear that the A.C. car, which has so many users in the aviation world, is steadily building up a remarkable reputation, thanks to the policy of the governing director, S. F. Edge, which is to prove by R.A.C. trials and other public tests that everything claimed for the car can and will be done by any A.C. car sold for the purpose to any buyer. This was demonstrated recently by an interesting R.A.C. test, in which a list of 47 A.C. agents was supplied to the Club, who selected from one of these one of the 11·8 h.p. model *de luxe* two-seaters from stock for the test. The engine was then run continuously for 48 hrs. 9½ mins., during which time the car was voluntarily stationary for 1 hr. 22 mins. A distance of 1,436½ miles (between Hounslow, Reading, Hook, Hounslow and on Brooklands Track) was covered at average speeds of 20 m.p.h. on the road and 41·4 m.p.h. on the track. The petrol consumption was 29·2 m.p.g. and the oil consumption 655 m.p.g. After the car was obtained from the agent it was kept under R.A.C. observation, and the driver only went over the various points of the car in the ordinary way. Occasional sticking of the throttle barrel was the only trouble experienced. In short, it gave a very good account of itself !

- - -

AN opportunity occurs to secure the services of an experienced publicity specialist who is presently making a change. Any of our readers interested we shall be pleased to place in communication with him. He is an experienced organiser, writer of copy and catalogue compiler, and for preference would like to arrange part time with any firm which does not really need a full-time man, to control the advertisement section. A line to "Progress," c/o of the Editor of FLIGHT, will at once reach its destination.

SOCIETY OF MODEL AERONAUTICAL ENGINEERS
(London Aero-Models Association)

THE debate held at Headquarters last Friday, opened by Messrs. Burchell and Rippon, on "Large Models and Small Models" proved so interesting that it is found necessary to continue same on Friday, December 1. On Friday next Dr. Hankin will give a lecture on "The Evolution of Animal Flight," illustrated by lantern slides. On Friday, December 8, a smoking concert has been arranged at Headquarters, under the direction of Mr. Louch and Mr. Levy. We are again indebted to Mr. Louch for kindly providing the artistes.

The Competition Secretary reports that the competition for the Pilcher Challenge Cup held on Hackney Marshes was disappointing, on account of the number of entrants being less than contemplated. No member qualified with the 20-secs. R.O.G., Mr. C. Hersom being nearest with 17 secs., Mr. F. de P. Green coming next with 15 secs. On the other hand, there was a good exhibition of general flying ; all the enclosed models flew well hand-launched.

Mr. Rippon instituted an improvement on Pavely's system of "Kite launching" model gliders, by which method when the model has attained its greatest height, limited by the length of the towing line (about 150 ft.), the model is automatically released and a free glide follows. Mr. Howse was especially successful, the best of his glides being 57, 54 and 51 secs. Mr. Rippon tested a new light-weight glider, obtaining 23 secs. on 100 ft. of line.

Mr. M. Levy reports that on Saturday at Sudbury Flying Ground—Messrs. Rippon, Johnson, Green and himself being present—the conditions were bad for gliding, the wind being across the hill, Rippon's best flight being 25 secs. and Levy's 20 secs. Mr. Johnson had a large tractor.

Members are specially requested to be present on Wimbledon Common on Sunday morning next, when the Glider Competition for Dr. Hankin's prizes will be held. The Secretary of the Dutch Model Aeroplane, Mr. J. H. Van der Muelin, hopes to witness some good flying and gliding.

A. E. JONES.
Hon. Sec.

AERONAUTICAL PATENT SPECIFICATIONS

Abbreviations : **cyl. = cylinder ; I.C. = internal combustion ; m. = motor.**
The numbers in brackets are those under which the Specifications will be printed and abridged, etc.

APPLIED FOR IN 1921

Published November 30, 1922

12,968. F. P. H. BEADLE. Variable camber aerofoils. (188,007.)
19,857. H. E. S. HOLT. Coupling for securing life-line of parachute to harness on aviator. (188,031.)
20,385. D. J. MOONEY. Metal wings and lifting-surfaces. (188,055.)
29,799. P. J. GRIFFIN. Screw propellers. (188,206.)

If you require anything pertaining to aviation, study "FLIGHT'S" Buyers' Guide and Trade Directory, which appears in our advertisement pages each week (see pages iii and xiv).

NOTICE TO ADVERTISERS

All Advertisement Copy and Blocks must be delivered at the Offices of "FLIGHT," 36, Great Queen Street, Kingsway, W.C. 2, not later than 12 o'clock on Saturday in each week for the following week's issue.

FLIGHT

The Aircraft Engineer and Airships

36, GREAT QUEEN STREET, KINGSWAY, W.C. 2.

Telegraphic address : Truditur, Westcent, London.
Telephone : Gerrard 1828.

SUBSCRIPTION RATES

"FLIGHT" *will be forwarded, post free, at the following rates* :—

UNITED KINGDOM	s.	d.	ABROAD*	s.	d.
3 Months, Post Free...	7	7	3 Months, Post Free...	8	3
6 " " ...	15	2	6 " " ...	16	6
12 " " ...	30	4	12 " " ...	33	0

These rates are subject to any alteration found necessary under abnormal conditions and to increases in postage rates.

** European subscriptions must be remitted in British currency*

Cheques and Post Office Orders should be made payable to the Proprietors of "FLIGHT," 36, Great Queen Street, Kingsway, W.C. 2, *and crossed London County and Westminster Bank, otherwise no responsibility will be accepted.*